Stacked amplifiers lower noise

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You can realize an improvement in the signal-to-noise ratio of an amplification system by stacking the system's amplifiers—connecting their inputs in parallel and their outputs in series. In this configuration, the combined S/N ratio improves in direct proportion to the square root of the number of amplifiers stacked. This improvement arises because the signals add arithmetically while the combined noise only increases as the square root of the number of amplifiers. However, it occurs only if the source voltage is not decreased by loading.

Stacked amplifiers have not been extensively used because of hardware considerations: You need transformers to add the outputs. However, if you use instrumentation amplifiers, you can add the outputs by feeding one amplifier's output into the reference input of the next.

The AD524 instrumentation amplifier is particularly well suited for this purpose. It features programmable gain, low noise, high input impedance and wide-band response. **Fig 1** shows two AD524s configured in the stacked configuration, providing a 3-dB increase in S/N ratio compared with one amplifier. You can achieve a final improvement in the S/N ratio by using the 524's ultralow-noise version, the AD624, which features a 4-nV/$\sqrt{Hz}$ front end.

You can also modify **Fig 1**'s circuit to produce an active balanced transformer **(Fig 2)**. This circuit provides the same 3-dB noise improvement because,

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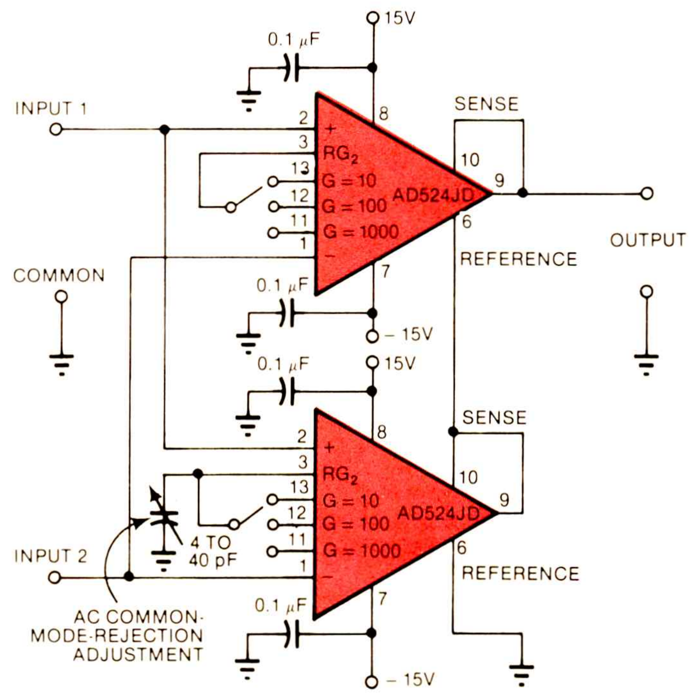

Fig 1—Stack two instrumentation amplifiers *to obtain a 3-dB improvement in S/N ratio. The output of one feeds into the reference input of the next, so the output levels add.*

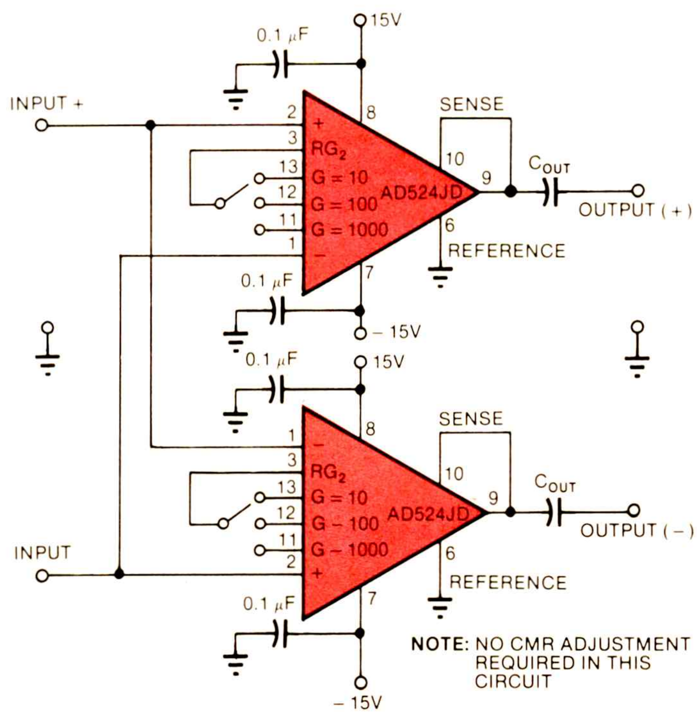

Fig 2—Modify Fig 1's circuit *to form an active balanced transformer. This arrangement still realizes the improvement in S/N ratio that's characteristic of stacked amplifiers.*

COMPARATIVE PERFORMANCE OF FIG 1 AND FIG 2 CIRCUITS

PARAMETER	FIG 1	FIG 2
SLEW RATE	5V/μSEC	10V/μSEC
MAX OUTPUT LEVEL	20V P-P (7.1V RMS)	40V P-P (14.2V RMS)
– 3-dB BANDWIDTH AT 1V P-P OUTPUT FOR GAIN = 2 (6 dB) FOR GAIN = 20 (26 dB) FOR GAIN = 200 (46 dB) FOR GAIN = 2000 (66 dB)	 DC-850 kHz DC-380 kHz DC-200 kHz DC-30 kHz	 DC-1 MHz DC-500 kHz DC-200 kHz DC-30 kHz
COMMON-MODE REJECTION RATIO (GAIN = 2, 20V P-P SINE WAVE COMMON-MODE INPUT LEVEL)	– 80 dB AT 60 Hz – 80 dB AT 10 kHz (WITH CMR TRIM)	– 93 dB AT 60 Hz – 83 dB AT 10 kHz
NOISE IN 20-kHz BANDWIDTH	0.6 μV RETURNED TO INPUT	0.6 μV RETURNED TO INPUT
TOTAL HARMONIC DISTORTION	<0.01%	<0.01%

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as in **Fig 1,** the signals add but the noise outputs don't correlate.

Note that **Fig 2**'s circuit, unlike a conventional transformer, does not provide galvanic isolation between its input and output unless both are ac coupled. In addition, if the inputs are ac coupled, you must provide a return path to ground via two large-value input resistors connected between each input and ground. The value of these resistors should be several times the source impedance. **EDN**

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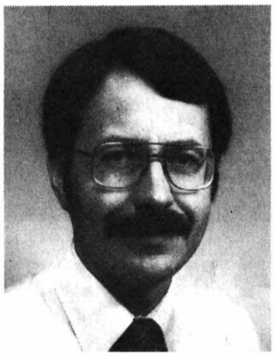

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